

Wastewater Treatment: The Natural Way

A system employing aquatic plants as water purification agents highlights spinoffs in environmental control and resources management

In the spring of 1985, the town of Haughton, Louisiana, faced a problem: the state Department of Environmental Quality had notified Mayor Harold R. Lee that Haughton's wastewater treatment facility was in violation of environmental protection standards.

It looked at first as though Haughton would have to lay out \$1.2 million for add-on modifications to its activated sludge facility—and also pay considerably more to operate the expanded facility. That would have been a heavy financial strain for the community of 2,000.

But Mayor Lee had an idea. He had read of the research of Dr. Billy C. Wolverton, head of the Environmental Research Laboratory at NASA's John C. Stennis Space Center (SSC) in Mississippi. Wolverton is widely acclaimed for his innovative work in natural water purification, which involves use of

aquatic plants to remove pollutants from wastewater at relatively low cost. Wolverton and his SSC group had developed a new and advanced technique known as the artificial marsh filtering system, which seemed a possible answer to Haughton's dilemma. Haughton officials contracted Wolverton, visited an artificial marsh test site and learned details of the operation. When they looked into relative costs of the two options, "The choice was clear," said the mayor; the NASA technology would permit development of a wastewater treatment facility that would allow for growth to almost double the town's population at a cost less than one-third the estimate for improving the old system.

The facility Haughton built is an 11-acre sewage lagoon with a 70 by 900 foot artificial marsh called a vascular aquatic plant/microbial filter cell. In the cell, microorganisms and rooted aquatic plants combine to absorb and digest wastewater pollutants, thereby converting sewage effluents to relatively clean water. Raw wastewater, after a period in the sewage lagoon, flows over a rock bed populated by microbes that digest nutrients and minerals from the sewage, thus partially cleaning it. Additional treatment is provided by the aquatic plants growing in the rock bed, which absorb more of the pollutants and help deodorize the sewage.

The Haughton facility went on line early in 1987. A year later, Haughton was able to reduce its sewer user fees by 25 percent. The facility was easily meeting the more stringent wastewater cleansing standards and there was a bonus: the system won an award in the *American City and County* magazine Awards of Merit.



Not a floral display, but a practical wastewater treatment facility—a field of floating water hyacinths that absorb and digest pollutants in wastewater, a technology that stemmed from NASA studies of water reclamation systems for long-duration spacecraft.



"To say that we are extremely pleased and proud of this facility would be an understatement," says Mayor Lee. "The artificial marsh rock-reed filter cost less to build, costs less to maintain and operate, and is much more efficient than any other system we could have built."

Haughton was among the first communities to employ the new artificial marsh technology but many other U.S. municipalities have benefited from SSC aquaculture techniques, which Wolverton and his group have been researching since 1974.

The program was initiated as a possible means of cleansing, detoxifying and reusing wastewater in space stations or long-duration spacecraft. Although a number of mechanical purification systems were—and are being—studied, SSC focused its effort on the ability of aquatic plants—notably the water hyacinth, which literally thrives on sewage—to absorb and metabolize astonishing amounts of nutrients and pollutants from wastewater. Use of water hyacinths offered potential bonus value because they could be harvested and used as fuel, fertilizer or as a protein/mineral additive to cattle feed.

After successful tests at SSC, the facility's neighboring community of Bay St. Louis, Mississippi, became—in 1975—the first municipality to employ aquaculture filtration. At the request of city officials, SSC fenced off part of the town's 40-acre wastewater lagoon and planted water hyacinths. The plants flourished on a feast of sewage

and in short order the once noxious lagoon became a clean aquatic garden.

SSC continues to work toward the primary goal of natural purification for space applications, but it is also engaged in assisting communities interested in aquaculture as part of NASA's Technology Utilization Program, which seeks to expand spinoff applications of NASA-developed technology. After the Bay St. Louis demonstration, SSC published a report of its work that attracted broad attention and inspired other communities to investigate aquaculture. Today, a number of southern U.S. towns, with populations ranging from 2,000 to 15,000, employ aquaculture as their year-round primary method of treating wastewater. Other towns—and one major city, San Diego—use aquaculture as a supplementary process in sewage treatment applications.

Because municipalities all over the nation are of necessity tightening their budgets, interest in the potential cost reductions afforded by aquaculture wastewater treatment is growing. And SSC's new aquatic plant/microbial filter process will allow a broader range of communities to take advantage of the technology. In fact, that is one reason why it was developed.

(Continued)

At Haughton, Louisiana, town officials installed a second generation version of NASA's natural wastewater treatment system. This one employs a combination of sewage digesting microbes living in a gravel bed and pollutant absorbing plants: bulrushes in foreground and canna lilies in background.



In this windowless, highly insulated facility, Stennis Space Center (SSC) is investigating the potential of natural air/water purification systems—plants—for facilities with reduced ventilation, such as space stations and energy-efficient homes/offices.

Water hyacinths are almost the ideal natural wastewater purification system. This free-floating freshwater plant grows prolifically, digests enormous amounts of pollutants and, in Earth applications, offers cost-effective sewage treatment with potential byproduct bonuses.

But for water reclamation and recycling in future spacecraft or space stations, the hyacinth's utility is limited. In closed environment facilities such as manned spacecraft, there must be a better means of removing potentially toxic chemicals from reclaimed water. SSC's extensive research pointed to the plant/microbial filter as a more effective technique for in-space wastewater treatment, toxic chemical removal and water reuse.

For Earth applications, the water hyacinth is similarly limited. It is a warm climate plant, not suitable for practical use in northern latitudes except with greenhouse protection, which reduces cost-effectiveness and is not always effective. All operating aquaculture systems are in the southern U.S.

However, the types of plants used in the artificial marsh system—bulrush, reed, soft rush, cattail, canna lilies and others—are cold and salt-tolerant, thus usable in wastewater systems in colder climates. The first community demonstration of that potential is underway in Monterey, Virginia.

Monterey, population 249, is technically a southern town but it is perched in a high valley of the Allegheny Mountains at 3,000 feet, thus has colder than average winter temperatures. Monterey creates no significant pollution, but like all U.S. municipalities was required by the federal Clean Air Act to provide secondary sewage treatment by July 1, 1988. The estimated cost for a conventional facility was \$500,000, far beyond the means of the town's 149 sewer users.

Looking for an alternative, Monterey contacted SSC's Dr. Bill Wolverton and learned of aquaculture. Initially, it was thought that a water hyacinth lagoon, protected by a greenhouse cover, would serve Monterey's purposes. But after a summer's test of a hyacinth pond met with limited success, Wolverton recommended the still-new plant/microbial filter.

After much study and discussion with NASA participation, the Virginia Health Department and State Water Control Board approved experimental operation of the artificial marsh and Monterey won an extension of the deadline for compliance. Conversion of the hyacinth pond to a plant/microbial filter system got under way in 1988 and the town expects its system to be fully operational by 1993. Monterey Mayor George E. McWhorter Jr. thanked NASA for the work done by Wolverton and SSC, adding that

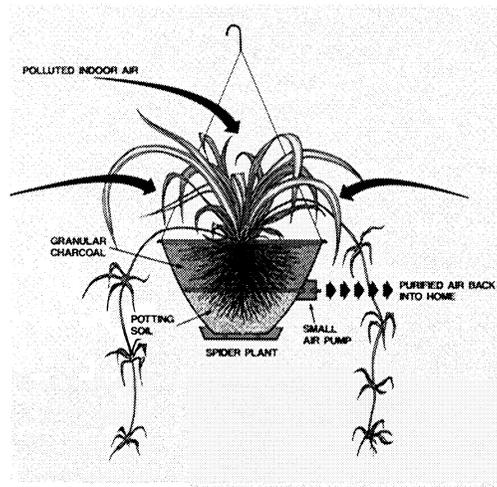
the technology "will enable the Town of Monterey and many other municipalities with the same problems to meet mandated standards at a cost far less than conventionally accepted methods."

Meanwhile, Wolverton's work has produced another spinoff technique, this one for purifying air as well as water in indoor environments. A substantial air pollution problem exists when ventilation is significantly reduced, as in pressurized long-duration spacecraft or highly insulated Earth buildings. In an effort to develop a practical means of preventing buildup of gaseous toxic substances in space stations or in airtight homes and office buildings, SSC is again evaluating the natural approach—in this case the use of common houseplants as air cleaners.

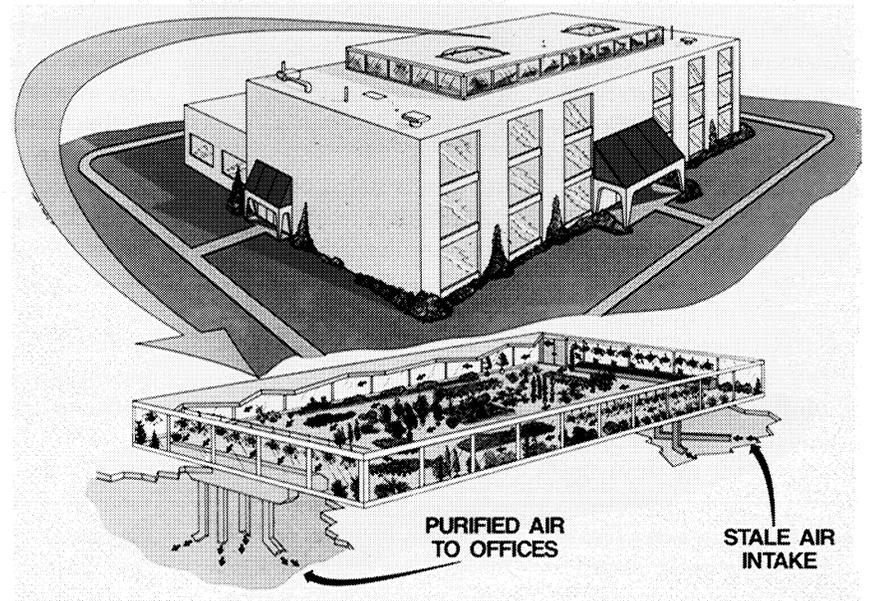
The potential health hazard in energy efficient homes stems from reduced ventilation and increasing use of resins and solvents in modern construction; they cause an increase in such indoor air pollutants as formaldehyde. Additionally, combustion of fossil fuels—as in cooking—and tobacco elevates home and office levels of carbon monoxide and nitrogen dioxide.

Branching off from its research on aquatic plants for wastewater treatment, SSC studied the use of foliage plants for air filtration and purification. The common spider plant was found to be particularly efficient in absorbing formaldehyde, nitrogen dioxide and carbon monoxide; other plants showed potential.

At a special facility at SSC, Wolverton's environmental research group is testing a number of plant types and developing concepts for Earth-use natural air purification systems. Commercial businesses are watching the effort and independently looking into ways of combining natural and mechanical filter systems to remove both particulate and gaseous indoor pollutants; two companies are now selling filter systems. ▲



The spider plant is one of several decorative houseplants that show promise for absorbing gaseous pollutants to clean indoor air.



A penthouse green garden serves as a natural purification system for "atmospheric revitalization" of an office building in this SSC concept. Efficient insulation designed to save energy may cause a health hazard in buildup of potentially toxic gases; a recycling system channels all indoor air through the garden, which absorbs the gaseous pollutants and returns clean air to the offices.